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Effect of Real Economy Predictors on Monetary Policy Responses: Testing Model Fits For OLS, IV and IV-GMM Estimators

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Abstract

The paper investigates the effect of real economy predictors on domestic monetary policy reaction function in Nigeria over the period of 1983 and 2018, using a quarterly data obtained from the central bank of Nigeria Statistical Bulletin. The evidence is based on the Ordinary Least Square (OLS), Two stages Least Squares (2SLS) and Generalized Method of Moment (GMM) estimators. The findings suggest that inflationary focus is necessary condition, but not sufficient as the welfare implication must also be built into policy reactions. Thus, it recommends that policy discretion towards improving the wellbeing; reduce productivity shocks and ensuring greater policy coordination is urgently required.

Key words

Monetary policy; Inflation; Productivity; GMM/IV, Nigeria

JEL Codes: F10, F15, F19, F21

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1. Introduction and literature review

Inflationary targeting by monetary authorities over the past ten decades has shown continuous fluctuation in inflation with consistent decline in the quality of life and welfare of the people from the African region. This has led to a drastic decline in survival rate. Literature has established the concern that the primary role of the Central Bank includes achievement of price stability, growth as well as employment (Adeoye and Shobande, 2017; Shobande, 2018b). There is however less agreement on whether the focusing on price stability in short run can ascertain long term growth and stability in exchange rate or reassure employment potential (Blanchard and Gali, 2008; Davies *et al.*, 2013; Dimand, 2013; Fatima, 2013; Woodford, 2007). This has remained a hotly debated issue among contemporary studies and formed the impetus for this study. In this policy paper, I present the argument that a worsen inflation expectation can enhance job creation, trigger saving mobilization and guarantee long term growth. I queried the basis of inflationary targeting policy as it creates distortion in the labour market and pose huge cost on survival rate in Nigeria. I claimed that a shift in policy attention from aggregated demand policy response to supply oriented framework is required. I also established that if the erosion in inflation targeting policy continued, the cost of wellbeing in Nigeria might begin to question the rationale for having a Central Bank without policy autonomy. I suggested that Central Banks need to encourage sustained economic growth, savings accumulation and backup economic diversification.

One of the often-cited postulations in macroeconomics literature is that economic stability ought to trigger sustainable growth outcome. This view is mostly pronounced with (Taylor, 1993, 1999, 2010), who earlier argued that Central Bank needs to curtail inflation in order to prevent financial crises and normalize the economy. In stark contrast to the benevolent theoretical conjecture, findings by Lucas (1987, 2003) queried the relevance of inflation targeting policy on welfare ground. Lucas (1987, 2003) estimated the cost of fluctuation in the United States and observed that removing fluctuation in the US economy will improve welfare by sixty eight percent during the period. On the basis of this empirical evidence, Lucas argued that a shift in aggregate demand policy is necessary to enhance job creation and mobilize saving potential.

While price stability seems necessary, the cost of living must not be taken for futility. For instance, when the Central Bank expands or contrast monetary policy rate, it has implication on two major channels. First, it affects the output channel and in turn impacts negatively on consumption and results to uncertainty in investment decisions, consequently, allocation of resource in the economy pose huge challenges among economic agents (Adeoye and Shobande, 2017; Khou *et al.*, 2015). Second, if Central Banks contract the money supply, interest rates will be higher, causing a slowdown in borrowing and spending, which can lead to lower growth and employment. At the same time, this can influence or lower the inflation rate as well as control price levels (Bhattacharyya, 2012; Egwaikhide and Eregha, 2018; Khou *et al*., 2015; Shobande, 2018a).

Obviously, the point raised by Lucas (2003) must not be taken for granted in the present monetary policy debates. Recent studies by Khou *et al*. (2015) and Dongkoo Chang, Jaffar (2014) have shown that output growth has two major phases, which are perceived to be structural and cyclical components. The studies also established that policy rate changes by Central Banks are more likely to affect the cyclical component of output growth rather than the structural output potentials (Dongkoo Chang, Jaffar, 2014; Joseph and Shobande, 2018; Matsuyama, 2004; Shobande, 2017).

One likely challenge faced by monetary authorities has been the excessive use of aggressive monetary policies to normalize this system without due consideration to the impacts on the consumption of the people. The adversity is perceived when the wages available to a labour can no longer meet daily needs. At this point it becomes clearer that the justification for pursuits of inflation targeting have sent a feedback effect on the economy (Boivin *et al*., 2008; Woodford, 2007). The puzzle remains whether we can trust the Central Bank's ability to create job, normalize the economy and mobilize savings for domestic investment; or if Central Banks should be blamed for all regular fluctuations in the economy. On a second note, it can be thoughtful to think of incorporating the welfare function of the state as additional mandate as already being integrated in Cambodia (Khou *et al*., 2015) and Korea (Dongkoo Chang, Jaffar, 2014). In addition, it might even be useful to provide a useful guide to policy makers on the number of small and medium scale loanable fund that must be granted by Central Bank to ensure deposit money banks perform their intermediary function and Central Bank meets up with its supervisory expectation.

However, this target seems simple, but the capacity of those in affair coupled with the dynamic changes in macroeconomic condition must be negotiated with the monetary tools available. For theoretical reasons, it might be logical to assume like Woodford (2008) and Blanchard and Gali (2008) that claimed tradeoff between inflation and unemployment stabilization is dependent on labour market characteristics, but this assumption will not suffice in all cases. I presumed that this assertion should be regarded as empirical error in the ongoing debate on change monetary policy mandate. I will spell my reasons for disagreeing with this position. First, macroeconomic imbalance is always there, inflation uncertainty cannot be neglected, and welfare impact of monetary policy reaction cannot be excluded. But accepting a certain degree of fluctuation can be reconsidered to reduce productive shocks and create employment opportunities, mobilizing saving and allocating scarce resource to drive investment, as well as careful management of the exchange rate system.

Certainly, the present disagreement in literature demands urgent reconciliation of our earlier understanding of the dynamics of monetary policy and surprising development in macroeconomic and financial variables lately. Although previous studies have neglected this possibility that inflation is unlikely to be a good mandate of Central Banks, yet volume of research effort continued to chase inflationary targeting policy and yearly laurels as scholarship is presented with crown for ground breaking theories without impacts. As a departure, this present study contributes to literature in three-fold. First, I explore two miseries confronting monetary policy issues in Nigeria and argued for a shift inflation targeting to job creation focus. I argued that the slow growth recorded in the past three decades in Nigeria are the aftermath of wrong policy focus. I blame the Central Banks for targeting inflation expectations even when we all know that increase in average rate of inflation brings about more uncertainty about future inflation. It is not likely that monetary policy can act as catalyst for reducing inflationary pressure given the peculiarity of Nigeria as a net exported of consumable goods. Consequently, the possibility of external shock is evident due to price fluctuation and the lacuna in current account imbalance as well as lack of fiscal discipline on the part of government. On a second though, research activity has consistently visit and revisit the relationship between inflationary expectation and real economic activities, but it appears that appropriate explanation to manage the inflation prediction cost more uncertainty than ever imagined.

2. Methodology of research

2.1. Model

Based on the theoretical intuition of Taylor rule for monetary policy and the empirical three Taylor equation model of Nechio *et al.* (2018) the baseline model for this present study is specified as :

$$R_t^{\,n} = \psi_0 + \psi_1 \pi_{et} + \psi_2 Y_{gt} + \psi_3 X_{rt} + \mu_t \quad (1)$$

Where the proxy for nominal interest rate $R_t^{\,n}$ standing for monetary policy responses, inflation is proxy as π_e stand for average annual inflation rate, proxy Y_g stand for average output growth rate, exchange rate is proxy as X_r which stand for average cost of exchange rate (real exchange rate). Meanwhile, Ψ_0, $\Psi_{1\text{-}2}$, are parameter coefficient, *t* is time, and μ_t is the stochastic term with expected zero mean and constant variance.

Re-specified as

$$\pi_{et} = \mathcal{B}\, E_t(\pi_{et} + 1) + \varrho Y_{gt} \quad (2)$$

$$\bar{Y}_{gt} = E_t(Y_{gt} + 1) + \frac{1}{\rho}(R_t^n - E_t(\pi_t + 1) - \bar{r}_t^r \quad (3)$$

$$R_t^n = \sigma_\pi \pi_{et} + v_t \quad (4)$$

Equation (2) describes the Philip curve that links the relationship between the inflation dynamics and the output gap, eq. (2) is the $\frac{IS}{LM}/BP$ that links the product, financial, and exchange rate market. Where, nominal interest rate is $R_t^n - E_t(\pi_t + 1)$, and $\bar{r}_t^r$ is real interest rate. The real interest is the interest rate consistent with maintaining economic growth at its trend rate and stable inflation (Monetary policy is essentially concerned with finding the interest rate – it gives best economic outcome of low inflation and economic growth).

Using the reduced form based on the concept of simultaneity, we have:

$$\pi_{et} = \theta_{\pi_v} v_t + \theta_{\pi_\varphi} \bar{r}_t^r, \quad (5)$$

$where,\ \varphi = \text{monetary shock}$ ((Nechio et al., 2018).

$$Y_{gt} = \theta_{y_v} v_t + \theta_{y_\varphi} \bar{r}_t^r, \quad (6)$$

Where, $\theta_{\pi_v}\theta_{\pi_\varphi}$, θ_{y_v}, and θ_{y_φ} are negative coefficients.

Using the GMM approach where the lagged of the variables are used as instruments. The matrix is stated as:

$$\chi_t = \begin{pmatrix} y_{gt} \\ \pi_{et} \end{pmatrix},\ B = \begin{bmatrix} \theta_{\pi_v} & \theta_{y_v}\sigma\theta^n{}_{y_\varphi}(1-\rho_\alpha) \\ \theta_{\pi_\varphi} & \theta_{y_\varphi}\sigma\theta^n{}_{y_\varphi}(1-\rho_\alpha) \end{bmatrix},\quad \Omega = \begin{pmatrix} \rho_v & 0 \\ 0 & \rho_\alpha \end{pmatrix},\quad \varepsilon_t = \begin{pmatrix} \epsilon_t^v \\ \epsilon_t^\alpha \end{pmatrix}, \quad (7)$$

Depend on the GMM assumption that the model is identified. Thus, ranking condition for identification is satisfied if and only if $\rho_v \neq 0$ and $\rho_\alpha \neq 0$ as the determinant of matrix

$M = B\Pi(B'B)^{-1}B = \rho_v\,\rho_\alpha$, identification requires persistence in the shock (Nechio *et al*., 2018). Though, the rank conditions are not adequate for reliable estimation and inference as queried by some studies who argues that estimate is likely of suffering from weak instrument (Matsuyama, 2004; Mavroeidis, 2005; Mavroeidis *et al*., 2014; Nechio *et al*., 2018; Stock *et al*., 2002). Stock *et al.* (2002) confirm that weak identification can lead to poor parameter and asymptotic results becoming a poor guide to actual sampling distribution. However, the strength of identification can be assessed using this concentration parameter as suggested by Mavroeidis (2005) and Stock et al. (2002), where the instrument signal to noise ration. Thus, this concentration parameter is apparent a unit ratio of the instrumental strong point and is stated as:

$\mu = \frac{\Pi' z' z \Pi}{\sigma_v^2}$, where $\boldsymbol{\mu} = f - statistics$ for testing the hypothesis and is estimates using the value of σ_v^2 (see Stock *et al*., 2002).

Following Thomas Rothenberg, as used by (Anderson *et al*., 2010, 2011; Bai and Perron, 2006; Fan *et al*., 2014; Mavroeidis *et al*., 2014; Stock *et al*., 2002), we obtained the 2SLS estimator as:

$$(\mu B^{2sls} - B) = \left(\frac{\sigma_\mu}{\sigma_v}\right)\frac{Z_\mu + {}^{S_{\mu v}}/_{\mu}}{1 + 2{}^{Z_v}/_{\mu} + {}^{S_{vu}}/_{\mu^2}}, \text{ where } Z_\mu = {}^{\Pi' Z' \mu}/_{\sigma_u\sqrt{\Pi' Z' Z \Pi}} \quad (8)$$

and

$$Z_\mu = {}^{\Pi' Z' v}/_{\sigma_v\sqrt{\Pi' Z' Z \Pi}},\ S_{\mu v} = {}^{v' P_z u}/_{\sigma_u \sigma_v}, \text{ likewise, } S_{\mu v} = {}^{v' P_z v}/_{\sigma_v{}^2} \quad (9)$$

This theorem holds under the assumption of fixed instruments and normal errors and standard normal random variable correlation.

2.2. Estimation Procedures

In this present study, we apply the classical econometric model Ordinary Least Square (OLS), Two Stage Least Square (2SLS), and IV-Generalised Method of Moment (GMM). This estimation strategy follows the work of Taylor (1999), Benk *et al.* (2008), Davies *et al.* (2013).

The first estimation techniques considered is OLS as used by Taylor (1999) in the contest of contemporaneous interest rate rule. Next is to consider that the expected future might likely correlate with the error term and we use 2SLS estimator (see Davies et al., 2013). The 2SLS procedure applied a Newey West adjustment for heteroscedasticity and autocorrelation (HAC) to the coefficient co-variance matrix (Kiefer *et al.*, 2000; Koichi Futagami *et al.*, 1993). However, expanding the instrument set in manner reduces the sample size but enable the validity for each of the instruments set to be assessed using Hansen J-Test. The GMM estimator adopted iterates on weight matrix in two steps and allowed us to conduct the HAC adjustment to the weighting matrix by accounting for Bartlett Kernel with a Newey-West fixed bandwidth (Kiefer *et al*., 2000). In line with economic theory that provides testable implication in form of moment restrictions, we apply the second instrumental variable procedure based on GMM estimator. Estimating Taylor rule with GMM, where the lagged of the variable are used as instrumental variables.

3. Data

3.1. Data Source

The study used quarterly data for the period 1983 Q_1 – 2018 Q_4, the data were sourced from the Central Bank's Statistical Bulletin, 2018. The quarterly data consist of nominal interest rate, output growth rate, inflation (consumer price index) and real exchange rate.

3.2. Data descriptions

Output growth rate: The Gross Domestic Product (GDP) growth rate measures how fast the economy is growing. It does this by comparing one quarter of the country's GDP to the previous quarter. The GDP measures the economic output of a nation. The quarterly output growth is important since it foretold how much more the economy produced than in the previous quarter (World Bank, World development Indicators, 2018). Nominal Interest rate: It is the lending rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to creditworthiness of borrowers and objectives of financing. I focus entirely on interest rate rules in which the short-term interest rate instrument of the Central Bank is adjusted in response to the state of the economy. Many interest rates coexist in an economy, reflecting competitive conditions, the terms governing loans and deposits, and differences in the position and status of creditors and debtors.

Inflation rate: Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as quarterly or yearly (World Bank, World development Indicators, 2018). Real exchange rate: Official exchange rate refers to the exchange rate determined by national authorities or the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar) (World Bank, World development Indicators, 2018).

4. Results

This section presents the results and discussion derived from the estimated model as earlier stated.

4.1. Preliminary Results

The summary statistics presented in Table 1, which include the mean, and standard deviation explained the essential properties of the data used. The need to pre-assess the descriptive properties of the dataset is crucial to determine the mean and variance, as well as ensure that data are independently or at least asymmetric in nature.

Table 1. Descriptive Statistics, 1983 Q_1 – 2018Q_4

Variable	Mean	Standard deviation
Nominal Interest rate (R^n)	6.84	4.17
Inflation (π_e)	14.93	81.4
Output (Y_g)	11.89	2.1
Real Exchange rate (X_r)	74.58	65.4

Source: Official data from the Central Bank Statistical Bulletin Report, 1983 Q1-2018 Q4.

Source: Computed by the Investigator, 2019.

Similarly, Table 2 presents the reports of the correlation coefficient that described the nature and behaviour of the dataset.

Table 2. Significant Correlation Matrix

Variable	Pearson Coefficients R^2
$R^n \leftrightarrow \pi_e$	0.45
$R^n \leftrightarrow Y_g$	0.51
$R^n \leftrightarrow X_r$	0.58
$\pi_e \leftrightarrow Y_g$	-0.11
$\pi_e \leftrightarrow X_r$	-0.15
$Y_g \leftrightarrow X_r$	-0.74

***Source**:* Computed by the Investigator, 2019.

The Table 2 above indicates that interest rate has considerably high relationship with the inflation, output-gap and exchange rate. It is also obvious that the problem of multi-collinearity among regressors is eliminated, i.e., the independent variables are less correlated to each other. The study now proceeds to the test of stationarity of the variables checking if they are mean reverting at level.

4.2. Econometric Results

Initial Tests

In their study, Ng and Perron (2001) offered highly efficient four-unit root test statistics: MZa, MZt, MSB, and MPT. Both the Ng-Perron Modified Unit Root test and the Dickey-Fuller Generalized Least Squares results in Tables 3 and 4, respectively, show stationary variables at level or non-mean reversion. This suggests that statistical properties of the series such as mean, variance, autocorrelation, etc. are all constant over time. The result of the unit roots is useful as descriptors of future behaviour *because* the series is stationary.

Table 3. Ng-Perron Modified Unit Root Tests Results

Variable	MZA
R^n	-23.49*
1%	-23.80
5%	-17.30
π_e	-19.857*
1%	-23.80
5%	-17.30
Y_g	-67.45**
1%	-23.80
5%	-17.30
X_r	-59.69**
1%	-23.80
5%	-17.30

Note: Δ symbolizes that the variables are in their first difference. The asymptotic critical values of Ng-Perron Modified unit root tests are in their respective levels of significance. ** (*) denotes the rejection of the null hypothesis at 1 % (5%) significance level.

Source: Computed by the Investigator, 2019.

Table 4. Dickey Fuller-GLS unit root tests results

Variable	Results	Remarks
R^n	-3.79*	**I (0)**
1%	-3.53	
5%	-2.99	
π_e	-3.44*	**I (0)**
1%	-3.53	
5%	-2.93	
Y_g	-9.88**	**I (0)**
1%	-3.54	
5%	-2.99	
X_r	17.18**	**I (0)**
1%	-3.45	
5%	-2.99	

Note: Δ symbolizes that the variables are in their first difference. The asymptotic critical values of Dickey Fuller GLS unit root tests are in their respective levels of significance

***Note**:* Robust standard error in parentheses. **P< 0.1; ** P < 0.05; ***P < 0.001.*

Source: *Researcher (2019).*

4.3. Discussions

The analysis in this study is conducted using the Ordinary Least Square, Two-Stage Least Square and Generalised Method of Moment. The study intends to adopt the best model amongst these methods of estimation identifying the relationship subsisting on the variables. This study applied quarter time series to build up a model on the nominal interest rate regressed on inflation rate, exchange rate and output-gap. In order to avoid endogeneity problem in the model, Two-Stage Least and Generalised Method of Moment are carried using the lag of interest rate (dependent variable), lag of inflation and lag of exchange are used. For a consistent and efficient result, good instruments are inevitable important – correlating with endogenous regressors and at the same time orthogonal to the error terms. Since Ordinary Least Square is always plagued

by heteroscedasticity and the standard IV is also not exempted, the Generalised Least Square introduced by Hansen (1982). The GMM which makes use of orthogonality condition to allow for efficient 1 estimation in the presence of heteroscedasticity is used. To test the validity of moment restriction, the popular J-*test* is used associated with Sangan and Hansen.

Table 5. Empirical Results

Dependent Variable: Nominal Interest rate (R^n

Model	Ordinary Least Square (OLS)		2-Stage Least Square		Generalized Method of Moment (GMM)	
	Coefficient	***P-Value***	***Coefficient***	***P-Value***	***Coefficient***	***P-Value***
π_e	0.004620**	0.0090	0.011013**	0.0005	0.020036	0.0048**
Y_g	0.500033	0.0702	1.127238**	0.0000	1.294446	0.0001**
X_r	0.023083*	0.0110	0.000234	0.4076	0.254784	0.0269*
C	0.561352	0.8360	6.195422**	0.0095	6.697487	0.0454*
	F-Stat. = 19.98	J- Stat.= -21.56	F-Stat.= 20.47	J- Stat.= 2.01	F-Stat.= -	J- Stat.= 1.578917
			Inst. Rank= 4		Inst. Rank= 4	

Instrument Diagnostics and Test			
2-Stage Least Square		**Generalised Method of Moment (GMM)**	
Orthogonality	Regressor Endogeneity	Orthogonality (P-Value)	Regressor Endogeneity
P-Value = 0.1578	P-Value = 0.2858	P-Value = 0.1578	P-Value = 0.3664

Note: Robust standard error in parentheses. **P< 0.1; ** P < 0.05; ***P < 0.001*

Source: *Researcher (2019)*

Table 5 presents the baseline regression results obtained from the model. The results of the IV estimate suggest that inflation and output growth responses to nominal interest rates. Furthermore, the estimates also suggest that even if policy endogeneity plays a role, such policy transmit erosion to the real macroeconomic predictors through monetary policy variable. Hence IV provides credible evidence in view of the conduct of monetary policy in Nigeria.

Besides, the Generalised Least Square gave a more consistent and efficient results where the Ordinary Least Square was deficient resulting from the presence of endogenous regressor. The result also tested for J-Test for over-identification restrictions which were found valid. That is, the null hypothesis of the validity of the model failed to be rejected. The two major post-examination of 2-Stage Least Square and Generalised Least Square (Orthogonality and Regressor Endogeneity) confirmed that the instruments are not correlated with the error term and the endogeneity problem was strictly eliminated among regressors.

5. Conclusions

In this study we interact the OLS, 2SLS, and IV GMM to investigate the effect of macroeconomic predictors on monetary policy responses in Nigeria, using a quarterly data for the period of 1983-2018. Two major tentative conclusions can be drawn from my findings. First, I saw potential output growth in monetary policy responses. I foresaw the need to sacrifice some degree of inflation to enhance output growth, savings accumulation and cementing intermediary role of the financial sector, which will not only reduce boom bust cycle in the Nigeria but provide remedies for enhancing stability of macroeconomic predictors.

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